ISES Solar Charging Station

Engineering Analysis

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Overview

- Introduction
- System Analysis
- Solar projections
- Power analysis
- Updated Gantt Chart
- Conclusion

Introduction

- Sponsor is Dr. Thomas Acker
- Design a Solar charging station that can charge small electronic devices
- Two main subsections to the solar charging station
  - Control systems
  - Display systems
- Best overall systems is the pre-programmed display and the grid tie control system
- Still considering the battery control system

Charging Devices

- 6 laptops at 40W
- 6 cell phones at 4W
- A total of 264W is required to power all the devices simultaneously
- All devices should be capable of charging for 8 hours
- A total of 2112W-hours is required per day

Charge Controller

- Regulates the power from the solar panels to the batteries
- $Amps_{req} = Power_{\ panels}/Voltage_{batteries}$

- $Amps_{req} = \frac{792\text{W}}{48\text{V}} = 16.5\text{A}$

- A charge controller of 20 amps will satisfy our specifications

Inverter / Circuit Breaker

Inverter:

- Converts high DC voltage to low AC voltage
- A 1000W inverter will be used to allow for unanticipated loads

Circuit breaker:

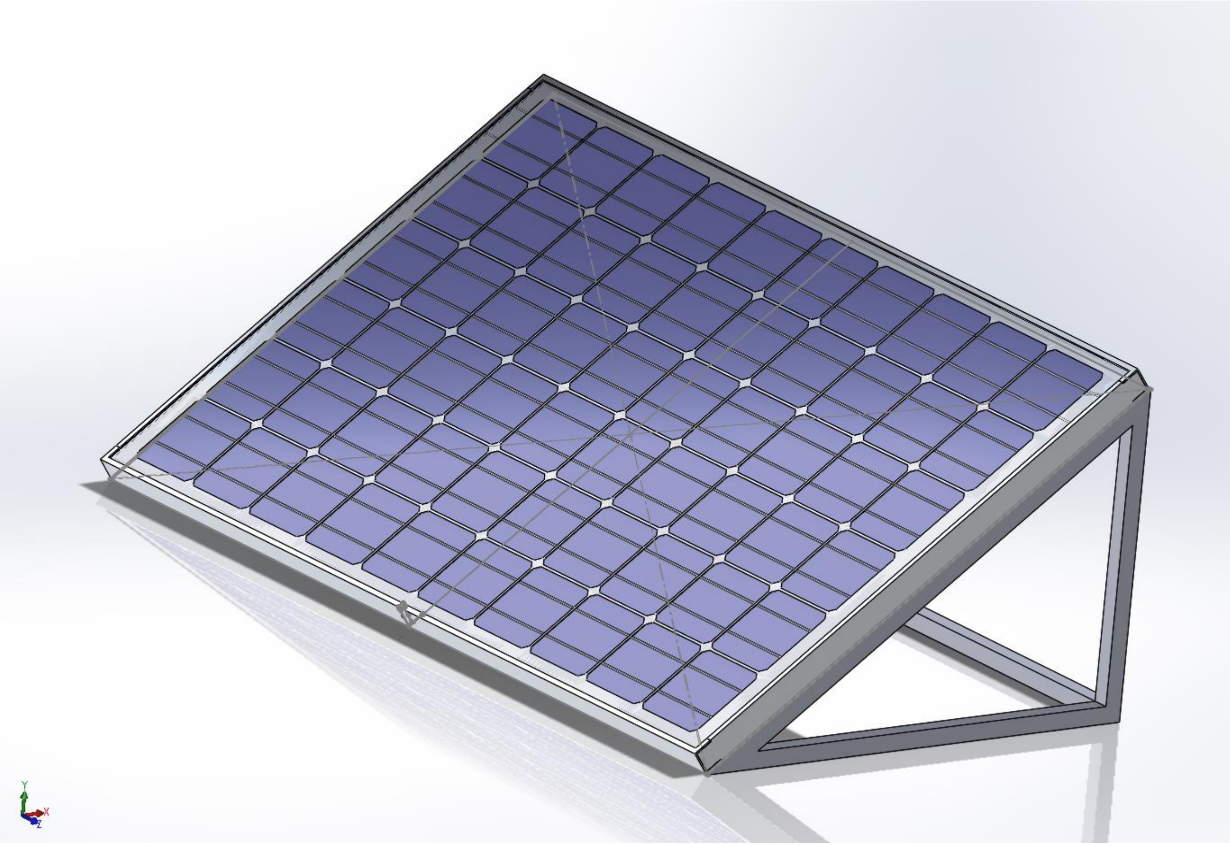
- Cut the power when the current is too high
- Based on the National Electric Code (NEC) The circuit breaker will be sized to 30 Amps

Battery Analysis

- The system requires 2112 Watt-hours per day
- $\frac{Watt-hours}{day} * days\ of\ autonomy * \frac{1}{depth\ of\ discharge} = total\ amount\ of\ watt-hours$
- Battery Bank Capacity = 9716 watt hours / 203 amp hours
- A 12V / 245Ah AGM Battery was selected
- Four batteries will be wired in series to achieve a system voltage of 48V

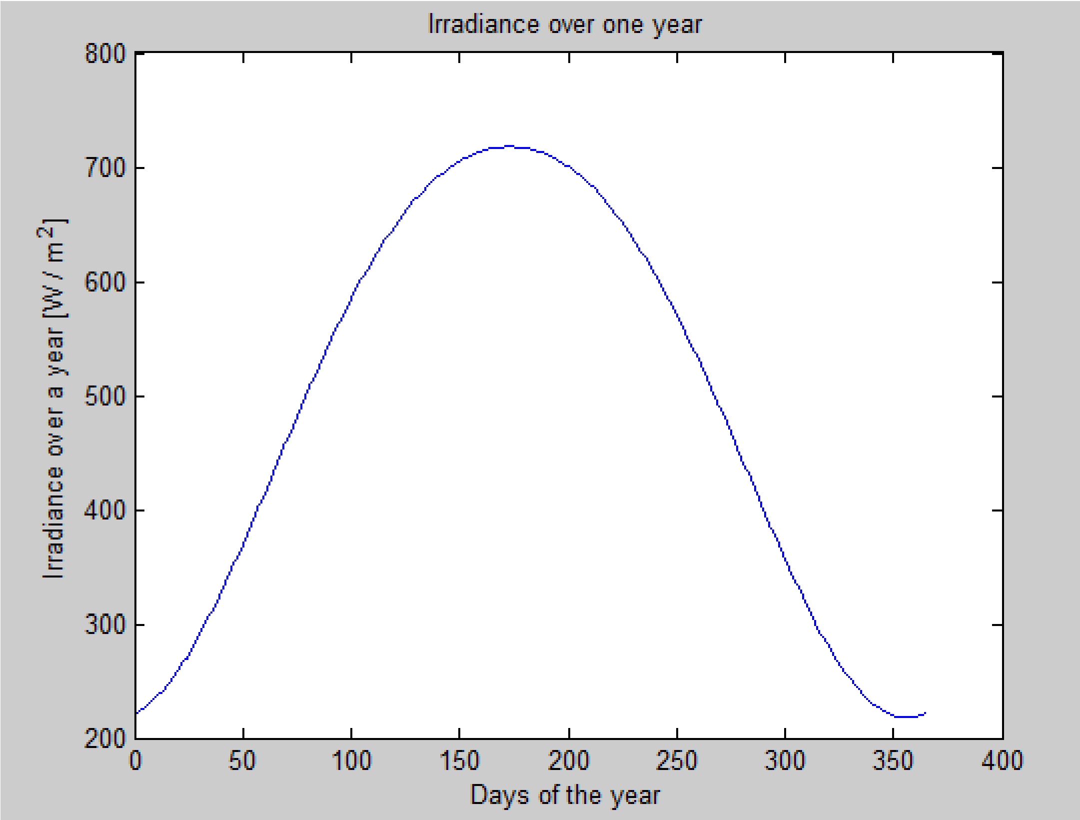
PV Panel

PV panel angled at 35°



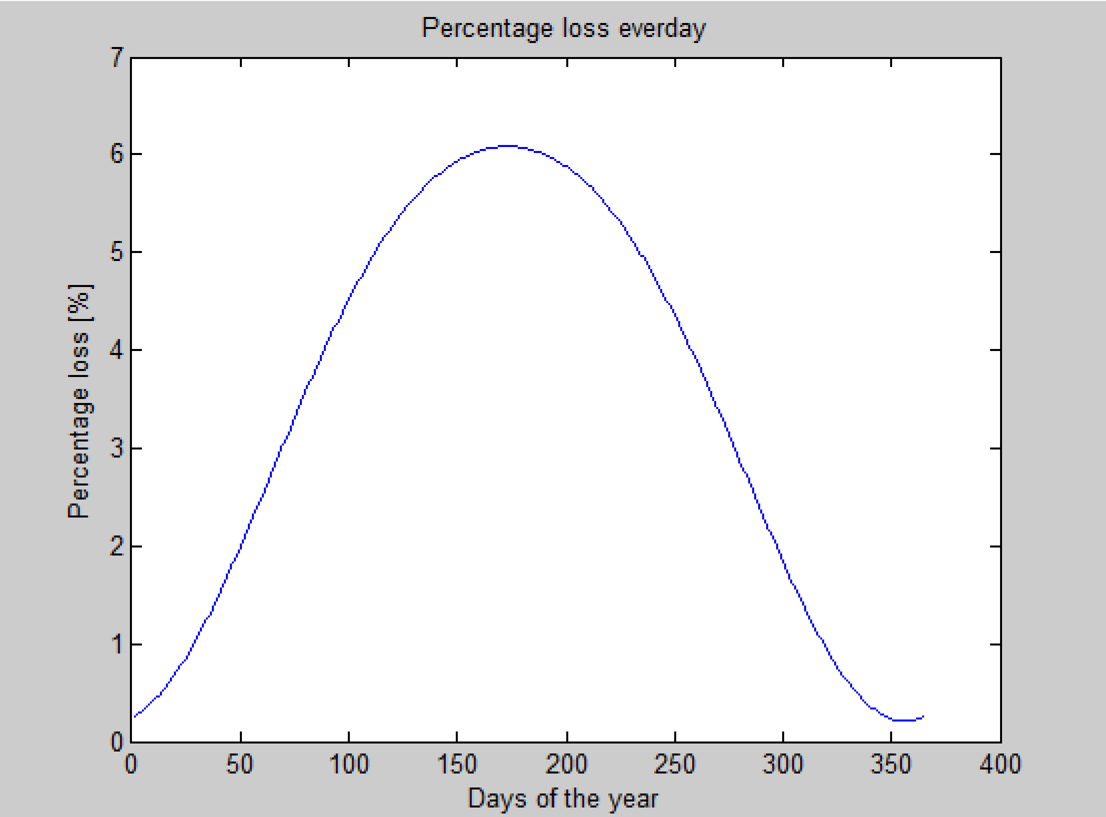
- PV panel are placed at 35° facing due south
- Based on Flagstaff latitude this is the best angle to maximize performance
- All of the figures that follow are calculated based on how the PV panel is oriented

Irradiance



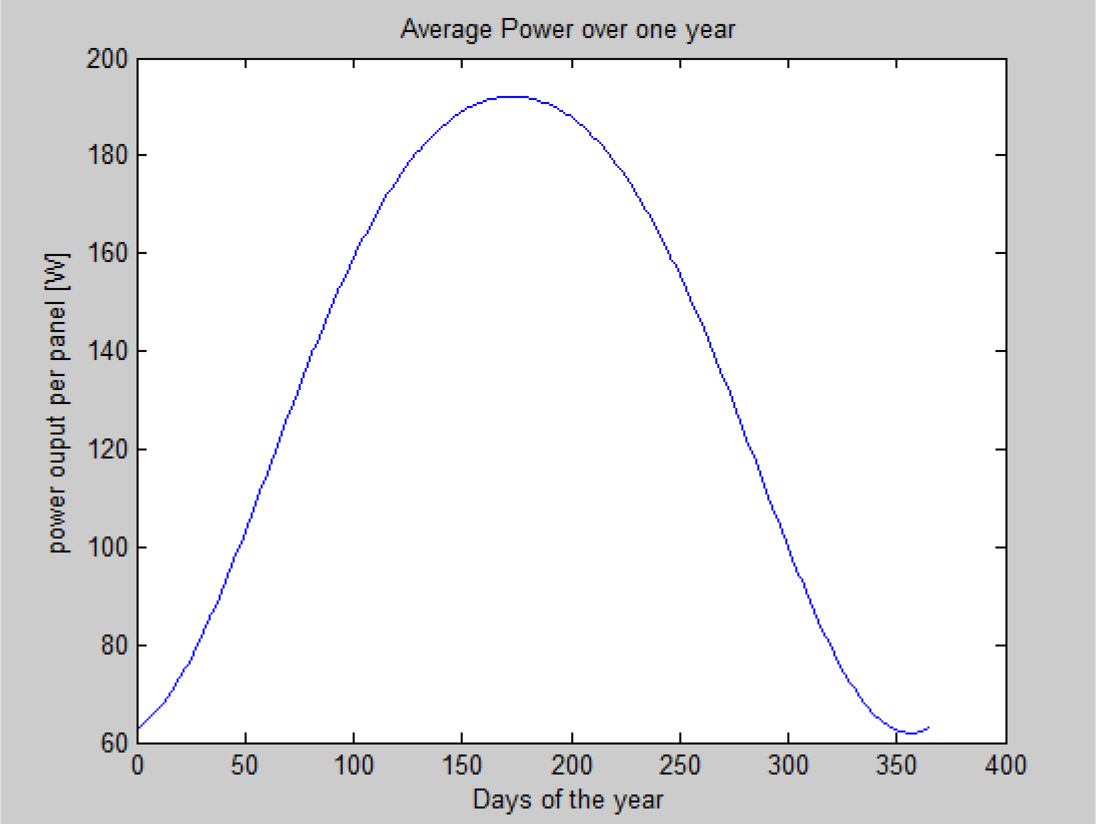
- Irradiance is lower in the winter than it is in the summer because of the number of daylight hours that are present throughout the year.
- The irradiance is based on the ideal irradiance of 1000W/m² and the zenith angle
- The zenith angle is the angle between the vertical and the line to the sun

Energy Loss



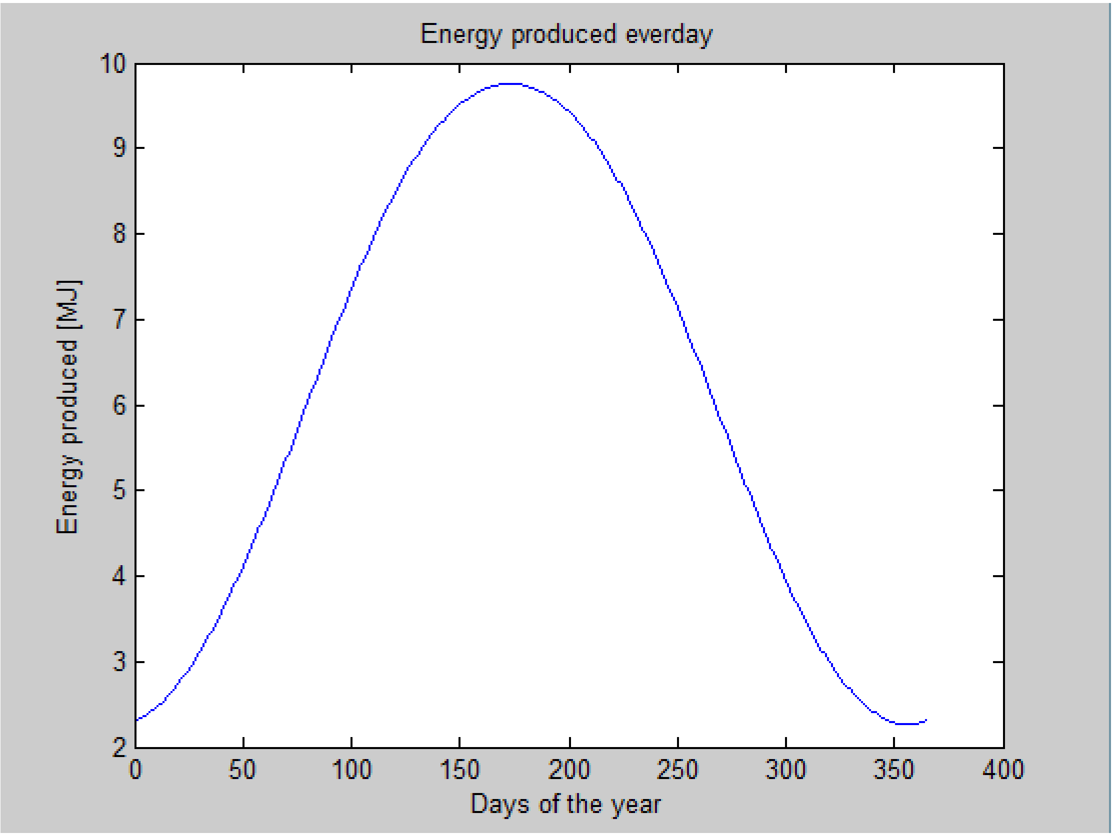
- Energy Percent loss represents the loss due to temperature differences
- The percent loss increases during the summer months because it gets hotter during that time due a more prolonged exposure to sunlight
- $Tcell = Tair + \frac{NOCT - 25}{800}$ x Irradiance
- $Percent\ loss = (Tcell - 25)$ x TCoP
- NOCT is the nominal operating cell temperature
- TCoP is the temperature coefficient of power
- TCoP = 0.47 % per ºC

Power



- The power output is determined based off of the irradiance going into the PV panel, and the losses experienced by the panel
- P = Irradiance x 0.3 x (1 - percent loss) x (1 – 0.05)
- The 0.05 takes into account dust and dirt build up on the panels.

Energy

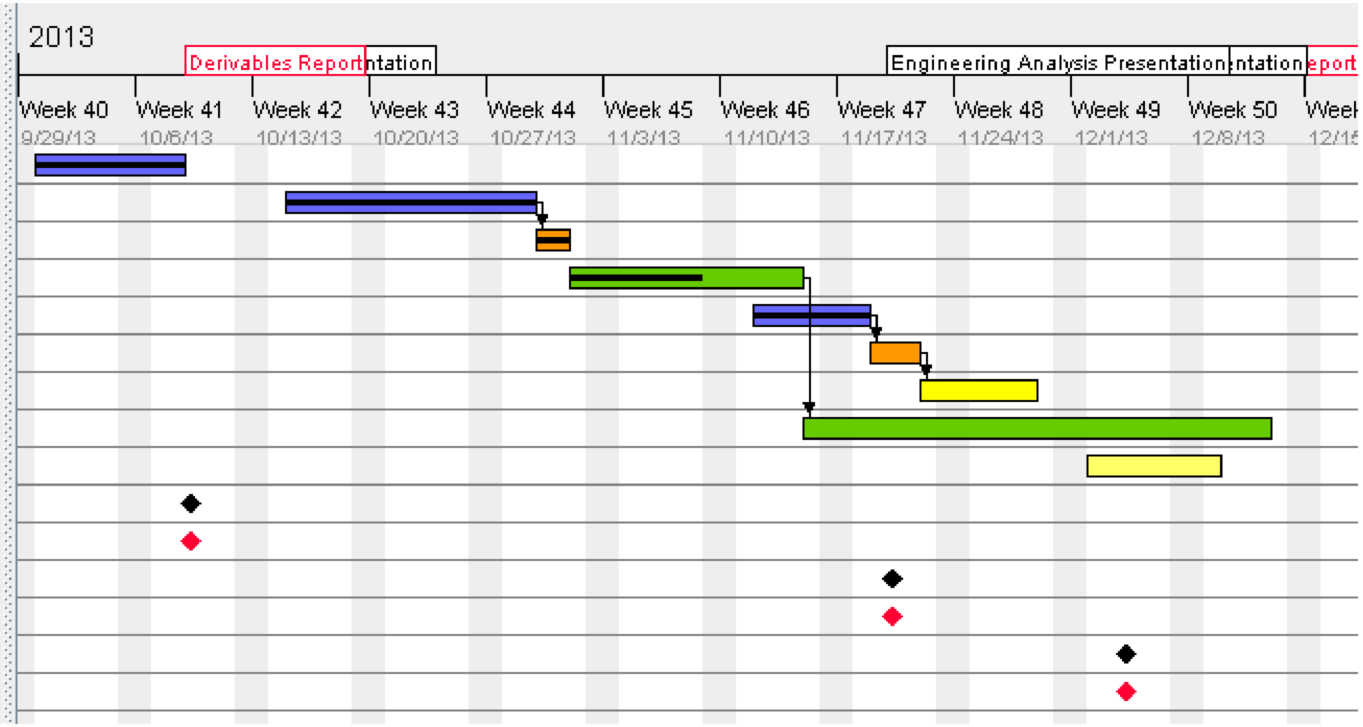


- Energy = Power x t
- Maximum is 9.53 MJ
- Minimum is 2.25 MJ
- Average is 6.00 MJ

Gantt Chart Update

Project timeline updated

Name	Begin date	End date
Identification of Specificatio...	9/30/13	10/8/13
perliminary Design	10/15/13	10/29/13
Create AutoCAD	10/30/13	10/31/13
Test Solar Panels	11/1/13	11/14/13
Secondary Design	11/12/13	11/18/13
Create AutCAD	11/19/13	11/21/13
Final Student Design Survey	11/22/13	11/28/13
Solar Analysis	11/15/13	12/12/13
Prepare submission for NA...	12/2/13	12/9/13
DeriverablesPresentation	10/9/13	10/9/13
Derivables Report	10/9/13	10/9/13
Engineering Analysis Pres...	11/20/13	11/20/13
Engineering Analysis Report	11/20/13	11/20/13
Final Presentation	12/4/13	12/4/13
Project proposal Report	12/4/13	12/4/13



Conclusion

- The station will be capable of charging 6 laptops and 6 cell phones simultaneously.
- The PV panel is going to be angled at 35° facing due south to maximize performance.
- A charge controller of 20 amps will be used.
- A 1000W inverter will be used to allow for unanticipated loads.
- Four 12V/245Amp-h batteries will be wired in series to achieve a system voltage of 48V.
- The average power output of one panel for one year is 132W.

References

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- "Choosing and Sizing Batteries, Charge Controllers and Inverters for Your Off-Grid Solar Energy System", Solar Town, http://www.solartown.com/learning/solar-panels/choosing-and-sizing-batteries-charge-controllers-and-inverters-for-your-off-grid-solar-energy-system/ , November 16, 2013
- "Circuit Breaker Sizing", Thomson Technology, http://www.nolensales.com/files/circuit_breaker_sizing.pdf, November 17, 2013

Questions?